



Frontier Radio Mk2p – Multi-Lingual: Enabling Versatile Space Comms

BACKGROUND

The Frontier Radio is a family of products developed by the Johns Hopkins Applied Physics Laboratory (APL) with NASA funding to support communication, navigation and radiometric measurements in spaceflight missions. These compact, low-power, software-defined radios can be tailored to specific mission needs and operate across a wide frequency range. Proven on missions to the Sun, Pluto and beyond, Frontier Radio offers flexibility, low power consumption and high performance in a smaller package than comparable systems.

MARKET NEED

There is a need for radios that are “multi-lingual” — in other words, that can communicate with each other using a variety of communications protocols. There is also a need

for operation in the K/Ka-band and at higher data rates. A spacecraft with a radio with these capabilities would be able to communicate with both commercial and NASA relay and ground communications systems at high data rates.

TECHNOLOGY SOLUTION

APL engineers have developed Frontier Radio Mk2p – Multi-Lingual (FR Mk2p ML), a wideband, high-data-rate, highly flexible new version of the Frontier Radio. FR Mk2p ML uses many of the blocks and technologies used in past instantiations of the radio and combines them with improvements in component technology. FR Mk2p ML’s higher processing power enables higher data rates and in-flight reprogrammability of both software and the field-programmable gate array (FPGA). A demonstration version of this radio was recently launched into low Earth orbit on the Polylingual Experimental Terminal (PEXT) mission in 2025.

FEATURES AND BENEFITS

FR Mk2p ML is compatible with the Space Network, the Deep Space Network, the Near Earth Network using Consultative Committee for Space Data Systems (CCSDS) waveforms, and commercial space relay providers using Digital Video Broadcasting - Satellite - Second Generation (DVB-S2) waveforms. The radio contains an optional general processing module (GPM) that runs a Linux operating system that can be used to implement higher-level protocols and advanced processing functions, such as delay-tolerant network routing, navigation and signal analysis. Radiation resilience is achieved through carefully selected components and onboard mitigations. The design practices used are compatible with risk-averse mission applications, and several



variants allow the customer to tailor the build quality and cost to their mission's needs.

TECHNICAL SPECIFICATIONS

- » **Mass:** <0.8 kg
- » **Dimensions:** 10 cm x 10 cm x 7 cm
- » **Frequency transmitter:** 25.25-31.0 GHz (commandable)
- » **Frequency receiver:** 17.7-23.55 GHz (commandable)
- » **Frequency options (build-time selectable):** VHF, UHF, L-, S-, C- and X-bands. Up to three simultaneous bands supportable by modem card.
- » **Receive noise figure:** ≤2.5 dB nominal
- » **Input supply voltage:** 22-36 VDC operational
- » **Input supply power:** Receive only, 8-24 W max.; transmit and receive, 14-32 W max. Lower-power configurations available for alternate bands and waveform loads.
- » **Data rates:** Return transmit up to ~880Mbps; forward receive up to ~230Mbps
- » **Waveforms supported:** DVB-S2, subcarrier, turbo and convolutional encoding, ranging and Doppler, and more
- » **Interfaces:** Redundant Host Ethernet, K-connectors for RF transmit and receive, SpaceWire, SpaceFibre, 1PPS, discrete signals

COMMERCIAL APPLICATIONS

Spacecraft can use this radio to communicate with existing ground modems to enable high-data-rate communication. NASA desires to discontinue government-owned relay services, and use of the FR Mk2p ML allows spacecraft to

communicate with relay and ground stations that are using a variety of waveforms. Because the radio's software and FPGA can be reprogrammed in flight, future waveforms can be loaded after launch to enable the most up-to-date waveforms.

FUTURE WORK

FR Mk2p ML migrates the PEXt flight demonstration into a unified, small form factor for the Frontier family. An optional GPM embedded within this platform is in development to complement the modem with additional processing resources. APL engineers are pushing the envelope to develop additional application loads, including advanced position, navigation and timing (PNT), communications, RF sensing and encryption functions. In addition, APL is currently refining the radio design for a commercialization phase and implementing improvements recommended from the flight demonstration.

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